

ICES 2014 Abstract

Title: CO₂ Washout Testing Using Various Inlet Vent Configurations in the Mark-III Space Suit

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Requirements for using a space suit during ground testing include providing adequate carbon dioxide (CO₂) washout for the suited subject. Acute CO₂ exposure can lead to symptoms including headache, dyspnea, lethargy and eventually unconsciousness or even death. Symptoms depend on several factors including inspired partial pressure of CO₂ (ppCO₂), duration of exposure, metabolic rate of the subject and physiological differences between subjects. Computational Fluid Dynamic (CFD) analysis has predicted that the configuration of the suit inlet vent has a significant effect on oronasal CO₂ concentrations. The main objective of this test is to characterize inspired oronasal ppCO₂ for a variety of inlet vent configurations in the Mark-III space suit across a range of workload and flow rates. As a secondary objective, results will be compared to the predicted CO₂ concentrations and used to refine existing CFD models. These CFD models will then be used to help design an inlet vent configuration for the Z-2 space suit, which maximizes oronasal CO₂ washout. This test has not been completed, but is planned for January 2014. The results of this test will be incorporated into this paper.

The testing methodology used in this test builds upon past CO₂ washout testing performed on the Z-1 suit, Rear Entry I-Suit (REI) and the Enhanced Mobility Advanced Crew Escape Suit (EM-ACES). Three subjects will be tested in the Mark-III space suit with each subject performing two test sessions to allow for comparison between tests. Six different helmet inlet vent configurations will be evaluated during each test session. Suit pressure will be maintained at 4.3 psid. Subjects will wear the suit while walking on a treadmill to generate metabolic workloads of approximately 2000 and 3000 BTU/hr. Supply airflow rates of 6 and 4 actual cubic feet per minute (ACFM) will be tested at each workload. Subjects will wear an oronasal mask with an open port in front of the mouth and will be allowed to breathe freely. Oronasal ppCO₂ will be monitored real-time via gas analyzers with sampling tubes connected to the oronasal mask. Metabolic rate will be calculated from the total oxygen consumption and CO₂ production measured by additional gas analyzers at the air outlet from the suit. Real-time metabolic rate measurements will be used to adjust the treadmill workload to meet target metabolic rates.

This paper provides detailed descriptions of the test hardware, methodology and results, as well as implications for future inlet vent design and ground testing in the Mark-III.